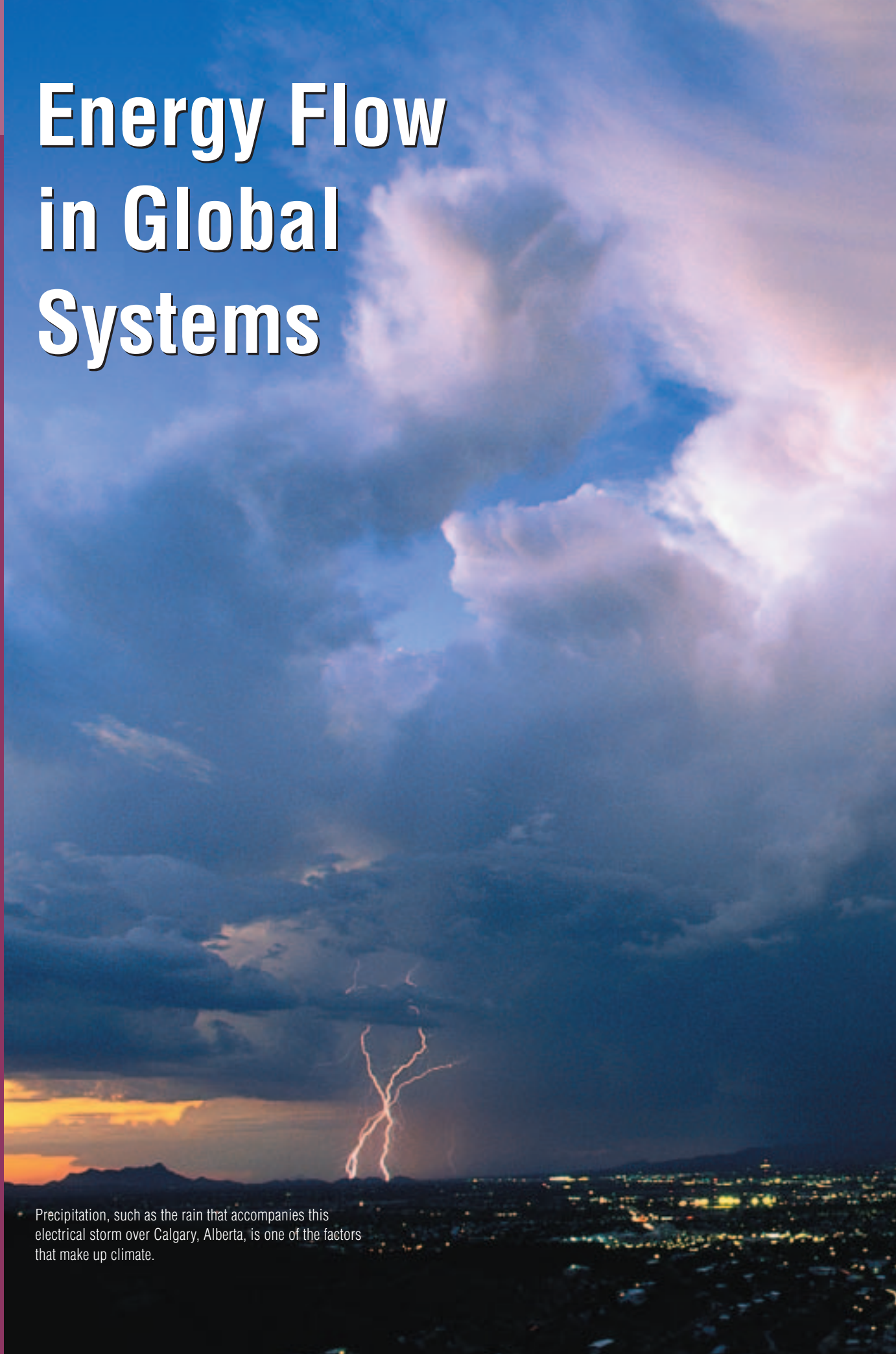
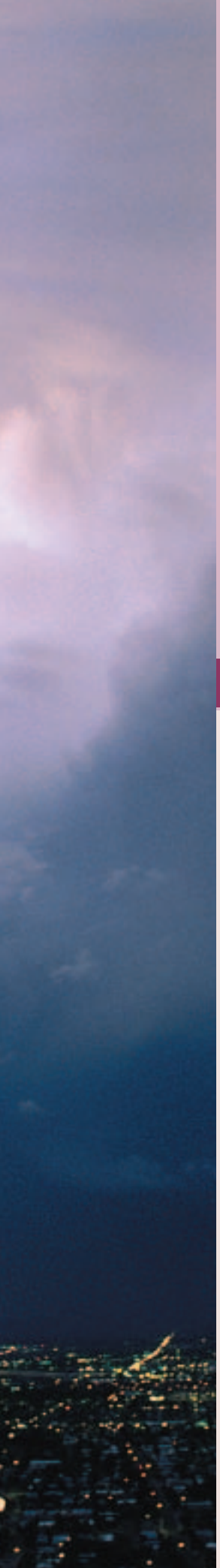
UNIT

D

Energy Flow in Global Systems



Precipitation, such as the rain that accompanies this electrical storm over Calgary, Alberta, is one of the factors that make up climate.



In this unit, you will cover the following ideas:

D 1.0 **Climate results from interactions among the components of the biosphere.**

- **D1.1** Earth—Our Biosphere
- **D1.2** Climate

D 2.0 **Global systems transfer energy through the biosphere.**

- **D2.1** Energy Relationships and the Biosphere
- **D2.2** Thermal Energy Transfer in the Atmosphere
- **D2.3** Thermal Energy Transfer in the Hydrosphere
- **D2.4** Earth's Biomes
- **D2.5** Analyzing Energy Flow in Global Systems

D 3.0 **Changes in global energy transfer could cause climate change, and impact human life and the biosphere.**

- **D3.1** Climate Change—Examining the Evidence
- **D3.2** International Collaboration on Climate Change
- **D3.3** Assessing the Impacts of Climate Change

Focus on Social and Environmental Context

During this unit, you will study how solar energy sustains life and drives global climate systems on Earth. Without solar energy, Earth would be cold and lack precipitation, so life as we know it could not exist. You will investigate how absorption and transfer of energy at and near Earth's surface results in a variety of biomes with specific climates. Once you understand the factors that affect Earth's global energy systems, you will be able to assess the evidence that has brought scientists to conclude that human activity can cause climate change—a change that could potentially harm the environment and our economy. As you work through this unit, think about the following questions:

1. Are there relationships between solar energy, global energy transfer processes, climate, and biomes?
2. How do global systems transfer energy through the lithosphere, hydrosphere, and atmosphere?
3. What evidence suggests our climate may be changing more rapidly than living species can adapt?
4. Is human activity causing climate change, and in meeting human needs, how can we reduce our impact on the biosphere and on global climate?

At the end of the unit, you may be asked to do these tasks:

Case Study Risky Solutions

You will research the costs and benefits of an emerging technology aimed at reducing or reversing the impact of human activity on Earth's climate. You will then analyze your findings, and decide whether further research on this technology deserves funding.

Project A Personal Plan for Reducing Carbon Dioxide Emissions

Using information provided, you will develop your own plan to reduce your and your family's carbon dioxide emissions by 2%. You will assess the economic and social costs of your plan on your family members, then report on your plan and its predicted outcome.

Exploring

■ Open water at the North Pole is a normal climatic event, and not a result of climate change.

In August of 2000, visitors to the North Pole were greeted by open water, instead of the usual solid ice. The thinning of the ice pack at the pole was picked up by the world's media as another example of the consequences of climate change. In fact, thawing of the polar ice sheets has always occurred periodically. However, the media response to this one event underlined the limits of our knowledge about climate, climate change, and its consequences.

We know that the average temperature on Earth's surface has increased over the last century. What is not yet clear is how quickly the climate is changing or its consequences. Climate change already appears to be causing significant consequences in some areas of Earth. For example, Inuit families in Canada's northern reaches are finding that their traditional igloo hunting shelters are no longer able to protect them from the cold. Warmer daytime temperatures are melting the snow of the igloos, which then refreezes to ice at night. Snow has better insulating properties than ice, so the refrozen igloos are much colder. In addition, meat from winter hunting is no longer staying frozen, but is thawing and rotting before it can be used.

These and other changes taking place in the Arctic are examples of the potentially global consequences of climate change. Climate affects many aspects of daily life, so scientists and governments are working to understand more about climate change and its causes. You might be surprised to learn that Earth's climate has changed before. Learning more about the causes and consequences of past changes in climate can help us to understand what is happening to our climate today, and also to predict its results. Scientists look for clues about Earth's past climate in many places. For example, one good source of information about past climatic conditions is the thick ice at Earth's polar regions. The ice in these areas has not melted for many thousands of years. Scientists drill out core samples from the lowest parts of this ice to get a glimpse of the conditions that existed when the ice first formed, about 2.6 million years ago. Evidence from ice core samples suggests that the climate at the poles was

much warmer in the past. Fossil evidence also supports this theory. For example, fossils of an extinct dinosaur, called a Champsosaur, have been found in the Arctic. The Champsosaur, a crocodile-like creature with a long nose and razor-sharp teeth, could survive only in regions with a warm climate, similar to that of present-day Florida.

Today, climate change may also be affected by human activities. To determine the extent to which we are affecting our climate, we need to understand the global systems that give Earth its climate in the first place, and the factors that can cause climate to change. This knowledge will help scientists to identify the causes of climate change today, and to predict its consequences.

■ A group of scientists, including members of Alberta's Royal Tyrell Museum of Paleontology, found fossils of Champsosaur in Canada's Arctic.

Activity D1

QuickLab

Climate and Tree Growth

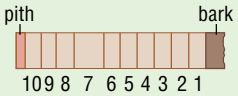
For every year of its growth, a tree produces a single ring of new wood in its trunk. The width of each growth ring is affected by the average temperature and moisture conditions during that year. Since trees can live many years, tree rings can be used to identify changes in the climate conditions of a region over long spans of time. In order to see the growth rings, scientists drill out core samples that extend from the centre of the tree (the pith) to the outer bark.

Purpose

To deduce the changes that occurred in the local climate of an area from the growth rings in core samples

Procedure

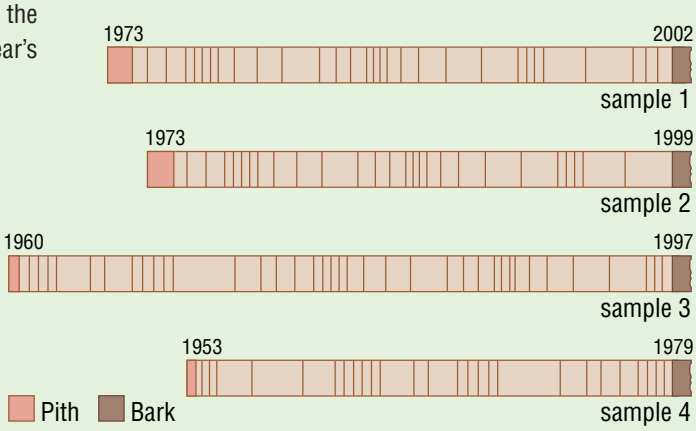
1. Since trees produce new wood just below their bark, the growth ring beneath the bark was produced in the last year of growth. The figure below shows how to determine the age of a tree from a core sample. Start counting from the bark inwards to the pith. The area between the lines in each core sample counts as one ring, or 1 year's growth, so this tree is 10 years old.



2. Create a chart with the following column headings: Sample, Age, Wet and Cool, Dry and Hot.
3. Look at the drawings of core samples taken from four different trees growing in the same area. Determine the age of each tree, and record it in your chart.
4. When a year was cool and wet on average, the trees produced wider growth rings. When a year was hot and dry on average, the trees produced narrower growth rings. For each of the core samples, deduce the time periods when each tree experienced cool and wet conditions and when each experienced hot and dry conditions. Record your deductions in your chart.

Question

1. Why would a scientist studying climate change be interested in the core samples from trees?



UNIT D

1.0

Climate results from interactions among the components of the biosphere.

Key Concepts

In this section, you will learn about the following key concepts:

- social and environmental contexts for investigating climate change

Learning Outcomes

When you have completed this section, you will be able to:

- describe the major characteristics of the atmosphere, the hydrosphere, and the lithosphere, and explain their relationship to Earth's biosphere
- explain how climate impacts on the lives of people and other species, and explain the need to investigate climate change; investigate how a species may be affected by an increase or decrease in average temperature

FIGURE D1.1 Scientists aboard the icebreaker *Des Groseilliers* spent a year collecting data on climate in the Arctic.

From October 1997 to October 1998, the Canadian Coast Guard icebreaker vessel *Des Groseilliers* drifted on the Arctic Ocean (Figure D1.1). Onboard, scientists and technicians from five different nations collected data on the Arctic's climate, as part of an international research project called the Surface Heat Energy Budget of the Arctic Ocean, or SHEBA. Their research was part of the ongoing worldwide effort to better understand climate, and the causes and potential consequences of climate change.

How is climate different from weather? **Weather** refers to the conditions of temperature, air pressure, cloud cover, precipitation (rain or snow), and humidity that occur at a particular place at a particular time. For example, today the weather in your area could be cold and sunny, but tomorrow the weather may be overcast and warmer. **Climate** is the average weather conditions that occur in a region over a long period of time, usually a minimum of 30 years. To describe the climate of Alberta, for example, you might say that the average temperature in summer ranges from 14°C to 20°C and in winter from −24°C to −9°C, and the average annual precipitation is 442 mm.

Why is it important to know about climate? What role does climate play in our lives and the lives of the other organisms with which we share our planet? In this section, you will find out about the central role that climate plays in keeping planet Earth a place that can support life. You will also learn about some of the evidence scientists have found that indicates our climate is changing, and consider some of the consequences climate change may have.

D1.1 Earth—Our Biosphere

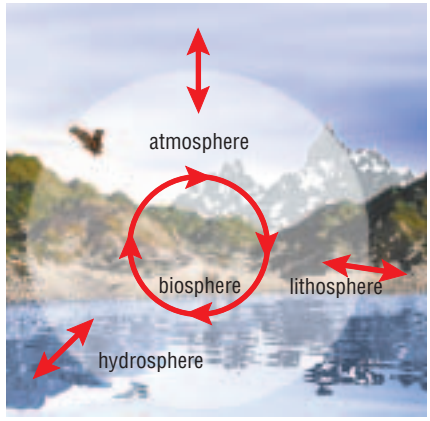


FIGURE D1.2 The biosphere is composed of all living things on Earth and the physical environment that supports them.

Earth appears to be unique in our solar system in that it is the only planet that supports many different living things. The **biosphere** is a relatively thin layer of Earth that has conditions suitable for supporting life as we know it. The biosphere is composed of all the living things on Earth and the physical environment that supports them.

The biosphere is made up of three interacting components: the atmosphere, the lithosphere, and the hydrosphere (Figure D1.2). The **atmosphere** is the layer of gases that surround Earth. The **lithosphere** is the solid portion of Earth, composed of rocks, minerals, and elements. The **hydrosphere** is all the water on Earth, whether it is present as liquid, water vapour, or ice. Living things are found in parts of all three components of the biosphere, wherever environmental conditions exist that can support life. These environmental conditions are in part created by the interactions between these components and incoming energy from the Sun, and between the components themselves, which you will study in this unit. These interactions create Earth's climate, which helps to maintain an environment that supports life.

The Atmosphere

The atmosphere rises over 500 km from the surface of Earth, and is mainly composed of a mixture of different gases (Table D1.1) that is commonly referred to as air. Figure D1.3 is a graph of the relative composition of the main gases in the atmosphere. Water vapour is also a gas found in the atmosphere, but in extremely variable levels. In this textbook, water vapour is considered to be part of the hydrosphere, and so is not included in Table D1.1 or Figure D1.3. The atmosphere also contains varying amounts of suspended particulate matter called **atmospheric dust** (solid particles less than 0.66 mm in diameter). These particles may include non-living particles, such as soot, or living particles, such as pollen and micro-organisms.

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If Earth had a radius of 120 cm, then the atmosphere would only be about the thickness of a line drawn in chalk.

TABLE D1.1 Percent Composition of Gases in Earth's Atmosphere (excludes water vapour)

Gas	Percent of Atmosphere by Volume
nitrogen	78.08
oxygen	20.95
other gases*	0.97

*includes argon, carbon dioxide, neon, helium, methane, and krypton

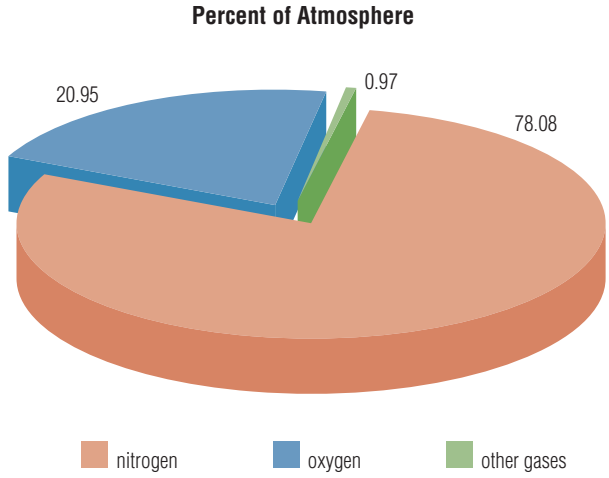

FIGURE D1.3 Most of Earth's atmosphere is composed of nitrogen gas.

Activity D2

QuickLab

Modelling Atmospheres

Purpose

To generate models of the atmospheres of Earth, Venus, and Mars, and compare their gas compositions

Materials and Equipment

graph paper, graphing calculator, or spreadsheet software

Procedure

1. The data in the table show the percent composition of gases in the atmospheres of Venus, Earth, and Mars. If you have access to a computer spreadsheet software or a graphing calculator, enter these data. Gases present in trace amounts should be entered as 0% for the purposes of this investigation.

Percent Composition of Three Atmospheres

Gas	Venus	Earth	Mars
carbon dioxide	96.5%	0.04%	95%
nitrogen	3.5%	78%	2.7%
oxygen	trace	21%	0.13%
argon	0.007%	0.9%	1.6%
methane	0%	0.002%	0%

2. Create graphs that visually summarize the differences in the atmospheres of the three planets. Test the effects of using different types of graphs in communicating these differences. For example, you could construct a pie chart for each planet using same colours for each type of gas on each planet chart. You might instead plot the data for all three planets on one bar graph, or generate one bar graph for each planet.
3. Choose the graph you think most clearly communicates the difference between the relative amounts of gases in the atmospheres of Venus, Earth, and Mars. Print out or redraw that graph in final form.

Questions

1. Explain why you think your choice of graph is most effective in communicating the differences between the atmospheres of the three planets.
2. Mars and Venus do not appear to have a biosphere. Summarize the main differences in the gas composition of Earth's atmosphere and of the atmospheres of Mars and Venus. Based on your summary, would you predict that Mars and Venus would be able to support life as we know it? Why or why not?

The most abundant gas in our atmosphere is nitrogen gas. Nitrogen is required for plant growth. Certain bacteria convert nitrogen gas into nitrogen compounds that can be taken up by plants. Oxygen is the second most abundant gas in Earth's atmosphere. Life as we know it would not exist without these levels of oxygen in the atmosphere. Living cells obtain energy through the process of cellular respiration, which uses oxygen to break down glucose molecules. The levels of oxygen gas are maintained through the process of photosynthesis, which uses the carbon dioxide that is produced by respiration and produces oxygen gas and sugars. Oxygen gas is also involved in many other chemical reactions, including combustion reactions (burning). Burning is the most common way that we release energy from fuel. The levels of nitrogen gas in our atmosphere help to control the amount of combustion that takes place, since nitrogen gas does not support combustion.

Earth's atmosphere can be divided into four layers, which are determined by the average air temperature. These layers are found at different altitudes (Figure D1.4). **Altitude** is the distance above Earth's surface, measured from sea level (the surface of the oceans). The altitudes shown are average values for Earth as a whole. The exact altitude at which a particular layer begins or ends above any point on Earth will be different for different locations or at different times of the day.

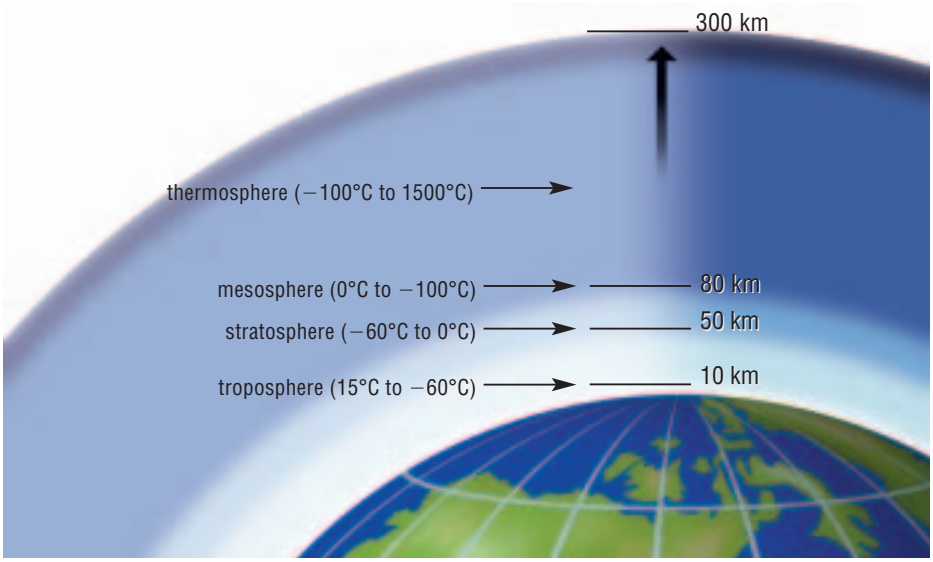

FIGURE D1.4 The layers of Earth's atmosphere do not have distinct boundaries, but blend into one another. Values are average altitudes for all of Earth, as stated by the Centre of Atmospheric Science at the University of Cambridge, U.K.

Troposphere

The **troposphere** is the layer of atmospheric gases at 0 km to 10 km from Earth's surface. The troposphere has an average temperature of 15°C at Earth's surface. The temperature of the troposphere decreases with increasing distance from the surface of Earth, and reaches a minimum of −60°C at the top.

The troposphere contains about 80% of the atmospheric gases by mass. It is the only layer of Earth's atmosphere with a temperature range and concentration of oxygen that can support many living organisms, including humans. The troposphere contains most of the carbon dioxide and water vapour in the atmosphere, and is the layer in which most weather occurs. The root of the word "troposphere" is the Greek word *tropos*, which means, "to change." The troposphere also contains almost all of the atmospheric dust. Atmospheric dust may be produced by natural events such as volcanoes and forest fires, and by human activity.

Stratosphere, Mesosphere, and Thermosphere

The **stratosphere** is the atmospheric layer above the troposphere, from about 10 km to 50 km above Earth's surface. The temperature in the stratosphere increases with distance from Earth's surface, starting at −60°C at the lowest part, to about 0°C at the top. Scientists have found clumps of cells in the stratosphere, but no other life.

FIGURE D1.5 Ozone is composed of three atoms of oxygen. Its formula is $O_{3(g)}$.

The stratosphere contains most of the ozone gas in the atmosphere. **Ozone** is a molecule made up of three atoms of oxygen (Figure D1.5). Ozone gas forms a layer in the stratosphere called the **ozone layer**. Ozone absorbs large amounts of energy from the Sun's rays, which causes the temperature in the stratosphere to increase with altitude. The ozone layer protects living organisms from damaging high-energy radiation.

The **mesosphere** is the third atmospheric layer above Earth's surface. The temperature of the mesosphere decreases from 0°C at the bottom to −100°C at the top. The **thermosphere** is the farthest layer from Earth's surface. The temperature in this layer increases from −100°C to as much as 1500°C. There is very little gas in these layers, and these temperature changes are not yet fully understood.

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Another way to classify the water on Earth is by separating the liquid water from the frozen water. By this method, the hydrosphere comprises all the liquid water on Earth, and the cryosphere comprises all the frozen water.

The Lithosphere

The lithosphere is the solid portion of Earth that floats above the semi-fluid portion of the upper mantle (Figure D1.6). The lithosphere is home to many micro-organisms, plants, and animals, including humans. It can be thought of as the outer surface of Earth and any solid portions of Earth's interior. The lithosphere extends from Earth's surface to about 100 km below, and runs under Earth's continents and oceans. The lithosphere is warmed mainly by incoming energy from the Sun and, to a lesser degree, by the molten material in the mantle.

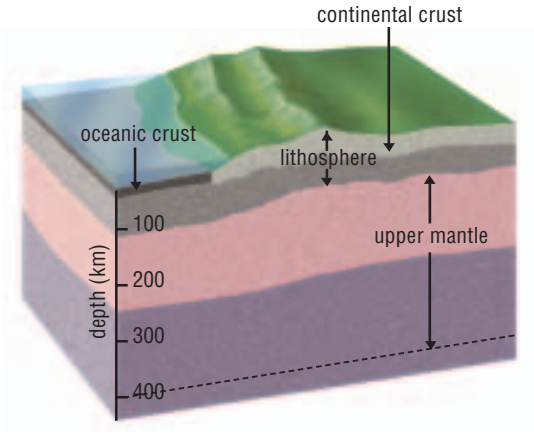

FIGURE D1.6 The lithosphere is the solid portion of Earth's crust. The lithosphere varies in thickness from as little as 5 km deep beneath parts of the oceans, to as deep as 100 km beneath the continents.

The Hydrosphere

The hydrosphere accounts for all the water on Earth. About 97% of this water is salt water in Earth's oceans. The other 3% is fresh water, and includes unfrozen water such as in lakes and streams, and frozen water, such as the ice in snow and glaciers. The amount of water on Earth always remains the same. Many different organisms, from whales to algae, live in the large water bodies of the lithosphere. However, the vast majority of the living organisms found in the lithosphere or atmosphere need water to survive, and so also depend on the hydrosphere. Like the lithosphere, the hydrosphere is warmed mainly by incoming sunlight and, to a small degree, by the molten material in the mantle.

FIGURE D1.7 Differences in the lithosphere can affect the amount of water vapour in the atmosphere, which changes the cloud cover.

The Components of the Biosphere Interact

Thinking about the atmosphere, lithosphere, and hydrosphere separately can be helpful for understanding the processes that occur on Earth. However, to understand the global systems of our planet fully, it is important to remember that these components continuously interact with one another. For example, water does not exist only in the hydrosphere. Water is also present in the atmosphere as water vapour, where it plays a role in cloud formation and other processes. It is present in the soil and minerals of the lithosphere, where, among other things, it dissolves plant nutrients and weathers rock. These interactions can change daily. For example, there may be as little as 1% water vapour in the atmosphere over a prairie ranch on a cold winter day, but as much as 4% over a large lake on a hot summer day (Figure D1.7).

Activity D3

Inquiry Lab

Student Reference 7

Required Skills
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Air Temperature and Altitude

If you have visited or seen pictures of high mountains, such as the Rocky Mountains in North America, you have probably noticed that some mountains are capped with snow year-round. Why are the tops of mountains always colder than the lower levels? In this investigation, you will create a graph of the air temperature measured on Sept. 3, 2002 at increasing altitudes above two Canadian cities. You will use this graph to explore the differences in air temperature at the top and bottom of a mountain.

The Question

How does air temperature vary with altitude above Port Hardy, BC, and Edmonton, AB?

Altitude and Air Temperature on Sept. 03, 2002

Port Hardy, BC		Edmonton, AB	
Altitude (m)	Air Temp. (°C)	Altitude (m)	Air Temp. (°C)
17	14.6	—	—
610	9.1	766	18.0
914	6.7	914	16.3
1 829	0.6	1 829	7.3
3 658	–11.0	3 658	–5.3
5 443	–23.9	4 914	–11.3
9 100	–42.3	8 535	–36.3
10 668	–45.4	10 621	–51.5

Source: University of Wyoming, Department of Atmospheric Science

Variables

Temperature is the responding variable. What is the manipulated variable?

Materials and Equipment

graph paper, spreadsheet software, or graphing calculator

pencils

Procedure

1. Graph the altitude and air temperature for both cities on a single graph.

Analyzing and Interpreting

1. Which city had the higher temperature at an altitude of 914 m? Which had the higher temperature at an altitude of 10 668 m?
2. Determine the air temperature at an altitude of 4000 m for both cities.

Forming Conclusions

3. Describe the general relationship between air temperature and altitude above these two cities.
4. Relate the trend of your graph of temperature versus altitude to the characteristics of the troposphere.

Applying and Connecting

5. Evergreen trees, such as firs and pines, cover much of the Rocky Mountains in Alberta. In contrast, much of the Laurentian Mountains in Quebec is covered with deciduous trees, such as maples and birch. The mountains of Alberta's Rockies have elevations up to 3700 km, but the mountains of the Laurentians have an elevation no higher than 520 m. Suggest one reason for the difference in the types of trees between these two mountain ranges.

reSEARCH

Find out what causes inversions, and why they often occur in mountainous regions. Begin your search at

www.pearsoned.ca/school/science10

Altitude and Temperature

Altitude is the distance above Earth's surface, measured from the upper surface of the oceans (sea level). In the troposphere, the temperature of the air tends to decrease with altitude. The temperature at high altitudes can be so cold that the tops of some mountains remain covered in snow year-round. In general, regions that are at higher altitudes tend to be cooler on average than regions at lower altitudes.

Sometimes, conditions in the atmosphere cause this pattern to change. An **inversion** is a reversal of normal temperature patterns seen in the troposphere. Inversions may trap unusually cold air close to the ground. Inversions tend to occur more often in areas close to mountains, where the air is forced to travel up over the higher elevations. There is also less air circulation during an inversion, which can cause pollutants to become trapped close to the ground. High levels of pollutants can affect the health of some people.

D1.1 Check and Reflect

Knowledge

1. Identify the following statements as examples of weather or of climate:
   a) Today is very hot.
   b) We usually get a lot of rain this time of year.
2. Write a short paragraph explaining the difference between climate and weather.
3. Describe the components of the biosphere.
4. What characteristics of the troposphere make it unique?
5. Identify the most abundant gas in the atmosphere.
6. How are the layers of the atmosphere classified?
7. In which part of the atmosphere does most of Earth's weather occur?
8. Does the lithosphere include just the land making up Earth's continents? Explain your answer.
9. Explain why temperature increases with altitude in the stratosphere.
10. Agree or disagree with the following statement: *The hydrosphere comprises only the water in the world's oceans, streams, and rivers.* Explain your answer in a short paragraph.

Applications

11. Make a chart that compares and contrasts the three parts of the biosphere.
12. Explain how each part of the biosphere supports life.
13. Using the data in the table below, construct a graph that clearly illustrates any similarities and differences between the gas composition of the atmospheres of Earth and Saturn.

Gas	Earth (percent by volume)	Saturn (percent by volume)
nitrogen	78	0
oxygen	21	0
helium	trace	11
hydrogen	trace	88
other	1.0	1.0

Referring to your graph, outline why our atmosphere is important to the existence of life as we know it.

Extension

14. Imagine that as part of your summer job, you are to participate in a scientific study of the biosphere. Write a short persuasive letter to the supervisors of the study, explaining which part of the biosphere you would like to study and why.

D1.2 Climate

If you ever have travelled between places with different climates, you have some idea of how climate affects your life. Your daily activities, clothing choices, even what you eat can change in areas with different climates. Climate also affects all other living organisms on Earth.

Climate Affects Daily Life

Alberta's climate has four seasons. In general, the summers are warm, winters are quite cold, and fall and spring can be very brief. The Northwest Territories, which share Alberta's northernmost border, are generally a lot colder than Alberta. How do differences in climate affect people's daily lives?

According to data from Statistics Canada, in 2001, Alberta had a population of 3 064 249 people in an area of 642 317 square kilometres, which is an average of 4.8 people per square kilometre. In the same year, the Northwest Territories had a population of 42 083 in an area of 1 183 085 square kilometres, or 0.036 people per square kilometre. A similar pattern is seen worldwide: regions with severe climates tend to have fewer people than regions with more moderate climates.

One reason that fewer people live in these regions is that severe climate causes additional challenges to everyday life. People cannot survive outdoors in extreme heat or extreme cold without adequate clothing (Figure D1.8). In Alberta's climate, people need one set of clothing to protect them from the summer heat, and a second set to protect them from the cold of winter.

Even with adequate clothing, people living in severe climates must seek shelter after a relatively short time in order to avoid injury, such as frostbite or sunburn. Their shelter must also suit the climate. Albertans' homes usually have some form of heating device, such as a furnace, which is used throughout the winter. In summer, heating is seldom used. Homes in Alberta generally are well insulated and have tightly sealed windows and doors, to help keep the temperature indoors different from that outdoors. The climate of Alberta also causes Albertans to use more fuel (and spend more money) to heat their homes than people who live in milder climate zones. For example, homes in regions of California often have only a space heater. The climate is so mild that residents may use their space heaters for only a few days in a year. Californians therefore use much less fuel and spend less money for home heating than Albertans. People in warmer climates may use more fuel or spend more money on air conditioning, however. Homes must also be able to withstand the amount and type of precipitation of a climate zone. Whereas homes in Alberta must be able to withstand the considerable weight of snow that can fall during winter, homes in areas with heavy rainfalls, such as in parts of Brazil, must be able to withstand these conditions (Figure D1.9).

Climate can determine the types of foods that are available in a region and the cost of that food. It is generally more expensive to buy fresh fruit in northern Alberta in January than it is in Florida, for example. Most fruit trees are unable to withstand the climate conditions of northern Alberta, so fruit must be transported to the region. The cost of transport increases the price of

FIGURE D1.8 The climate of the area in which we live determines what we need to survive.

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The first official weather observations in Canada were taken at King's College, University of Toronto, Toronto, Ontario, by members of the British Royal Artillery on September 6, 1840.

the fruit. Florida's climate provides good growing conditions for fruit trees, so this area produces many different fruits. These cost far less to transport to residents of Florida than to residents of Alberta.

The economic opportunities of an area can also be affected by climate. Think again about the example of producing fruit. In regions in Canada with warmer climates, such as the Okanagan Valley of British Columbia or the Niagara region of Ontario, fruit production is an important part of the economy. The economies of regions with colder climates, such as Fort Fitzgerald near Alberta's northernmost border, have little or no agricultural components. Tourism and recreation industries can also be affected by climate. Activities such as skiing or ice fishing are possible only in regions with a cold winter season. People in regions such as the Caribbean Islands depend on the year-round warmth of their climate to attract tourists interested in swimming and sunbathing.

Climate Affects All Organisms

Climate affects environmental conditions, and so all living things in any region are affected by climate. The species of plants that can survive in a region are determined by the climate. However, some characteristics of plants and animals can make them more suited or less suited to a particular climate. An **adaptation** is any change in the structure or functioning of an organism that makes it more suited to its environment. Different plants and animals have various adaptations that make them more suited or less suited to a particular climate. Think about the plants and animals of Alberta. How are they suited to Alberta's climate? How would their adaptations affect their ability to live in other climates?

Plant life in Alberta must be able to survive the seasonal changes in the climate. For example, many plants undergo a period of dormancy during the winter. Dormancy is a period in which growth of the plant ceases or becomes very slow. Deciduous trees, such as poplars, shed their leaves when they go dormant. This helps to protect them from freezing, and minimizes the amount of moisture they need. Plants cannot use frozen water, so winter is also a period of extreme dryness. Plants in Alberta will flower and reproduce only when temperatures are warmer and more moisture is available, usually

FIGURE D1.9 Home designs are altered to match the climate of the region in which the homes are to be built.

during spring and summer. In contrast, the climate in some tropical regions is warm and moist year-round. Plants in such tropical areas do not undergo a period of dormancy (Figure D1.10). Tropical plants continue to grow year-round, and many also reproduce throughout the year. Many plants in tropical climates cannot survive long dry periods, whereas plants found in dry climates are often unable to tolerate wet conditions.

The native animal life of a region is also affected by climate. Through food webs, plants ultimately supply food energy to all other organisms in a region. Earth's different regions, therefore, support different species of animals. For example, grizzly bears can find food in Alberta's mountains, but would be less able to find food in a desert. Animals also have adaptations that make them more suited to particular environmental conditions. Grizzlies can put on as much as 200 kg of fat during the summer months. This fat layer helps to insulate their organs from the cold of winter, as well as providing fuel. Grizzlies also make a den in a protected spot, such as a cave, and become extremely inactive during the winter. Contrast these adaptations with those of an animal native to a tropical region, the green iguana. The green iguana is cold-blooded, so it seeks out sunlight when the temperature is too cold and finds shade when the temperature is too warm. Instead of fur and insulating fat, the green iguana has a thick, water-resistant skin to protect it from the warm, wet climate of its home. Green iguanas are active all year round, since the seasons do not bring significant changes in temperature.

FIGURE D1.10 Plants and animals have adaptations that make them suited to the climate conditions of their home.

Minds On... The Importance of Climate

(a) Arctic wolf

(b) Trumpeter swan

(c) Purple lilac

FIGURE D1.11 What kind of climate do these species need to survive?

The organisms in Figure D1.11 have adaptations that enable them to survive in the climate conditions of their home. The Arctic wolf has a white coat year-round, which provides camouflage against ice and snow. The trumpeter swan nests only in wetland areas, which provide food and protection for its young. The purple lilac blooms very early in the spring, at the first hint of warmth, before many other plants.

In a group of two or three, brainstorm the effects of an increase in the average temperature of the regions where these organisms live. Consider factors such as the ability of the organisms to find food, water, and suitable shelter, and to compete with other organisms.

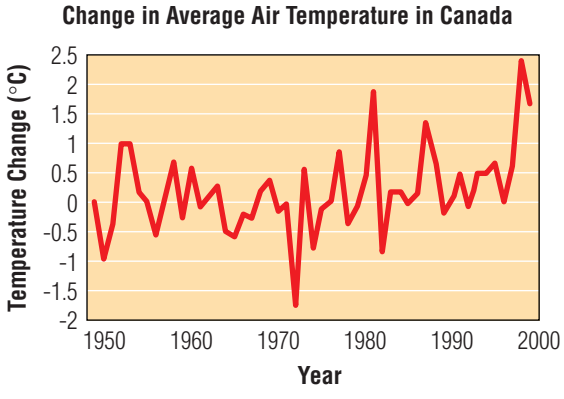
Write a summary statement on the importance of climate to living things, and the potential effects if the climate were to change quickly.

Climate Change

If one day in April happens to have a temperature of 29°C, does this mean that the climate is changing? No: the temperature on any one day is just a part of that day's weather. **Climate change** is change that occurs in the climate of a region over time, usually a minimum of 30 years. Scientists determine if the climate in an area has changed by comparing the average weather over the last 30 or more years with the average weather conditions over a similar period of time in the past. If every day in April had been warmer for the last 30 years than the average temperature in Aprils over the last 100 years, that would be strong evidence that the climate is changing.

Earth has experienced climate change a number of times in its history, according to evidence such as that from ice core samples and fossils. During some periods, the climate became cooler, and warmer during others. Today, the average surface temperature of Earth is increasing, according to two kinds of evidence: anecdotal evidence and scientific evidence.

Anecdotal evidence of climate change relies on reports from people about particular weather events and how they interpret these events changing over time. Anecdotal evidence is often useful, but it has not been carefully tested to ensure it is unbiased and that it applies to situations other than the particular events reported. For example, farmers in Alberta report that the growing season begins earlier now than it did years ago. Aboriginal and Inuit elders and leaders in Canada's north have also reported changes in weather events over time, including the first frost date, the start of animal migration, and the thickness of ice. These observations all suggest that the average temperature of Earth is increasing. **Scientific evidence** of climate change relies on evidence collected in a manner that, as much as possible, ensures it is unbiased and that reflects general situations, instead of just particular events. Scientific evidence is usually collected by trained scientists and is checked by other scientists. It often involves data collected using specialized instruments. Much of our evidence about historical climate conditions relies on anecdotal evidence, since keeping formal records and using specialized equipment to determine specific climate conditions in the past or present are relatively recent inventions. Anecdotal evidence and scientific evidence may provide information about the same or similar events. For example, scientists at Environment Canada have graphed the average yearly temperature in Canada from 1948 to 1999 (Figure D1.12). This graph provides scientific evidence that agrees with the anecdotal evidence: the average yearly temperature in Canada tends to be higher now than in the past. The data for this graph were collected from weather stations across Canada. The collected data were then used to calculate an average value for the whole of Canada, which was then plotted on the graph.



Data Source: Environment Canada

FIGURE D1.12 This graph provides scientific evidence of a warming trend in Canada's average air temperature, from 1948 to 1999. The zero point indicates that no temperature change occurred.

Activity D4

Decision-Making Investigation

Student Reference 10

Required Skills

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Climate Change Today

The Issue

Is climate change affecting present-day life in Canada?

FIGURE D1.13 Loss of permafrost is linked to increases in average temperature in northern regions and can cause significant damage to some structures, such as this railroad.

Background Information

As scientists collect and analyze data from many different sources, their understanding of climate increases. Some scientists predict that climate change may occur so quickly that some organisms will be unable to adapt. Even as you read this, the world's scientists are publishing new information related to climate and climate change.

For example, scientists at Environment Canada have suggested that if the average global temperature continues to increase, the amount of moisture in many regions in Alberta would decrease. These changes would affect the types of plants that can survive, which would in turn affect the organisms that depend on them for food and shelter. However, warmer temperatures would also increase the length of the growing season, which would allow some plants to grow in areas where they previously could not. In northern regions of Canada, such as the Yukon, Nunavut, and Northwest Territories, an increase in average temperature is predicted to cause melting of permafrost. **Permafrost** is permanently frozen ground, and thawing of permafrost can cause the ground to become unstable (Figure D1.13). A rise in the average temperature is also predicted to change the position of the tree line, the boundary between regions where trees can and cannot survive.

Working in small groups, collect articles and reports of current events related to climate change for regions in Canada. Use as many different types of information sources as you can to get current information, such as science journals and magazines, newspapers and news magazines, and Internet articles. When research is complete, create a class information board that incorporates all the information you have found. Arrange the information in a manner that will allow you to compare the information about the impact of climate change in different regions of Canada. You can create your information board electronically, using print materials, or both.

Analyze and Evaluate

1. Review the information on the class information board. In which region was human life most affected by climate change? Justify your choice.
2. In which region were other living organisms most affected by climate change? Justify your choice.
3. Severe or unusual weather events are not always due to climate change. Choose one severe or unusual weather event that is included on your information board. Summarize the evidence that links this event to climate change. Do you think the evidence is convincing? Why or why not?
4. You and your classmates can continue to add to the information board throughout this unit. At the end of sections D2.0 and D3.0, review any new information that has been added to the board, and repeat steps 1 and 2.

reSEARCH

Using the Internet, find evidence related to global climate change from current sources. This evidence may be about global climate change in the past or today. Begin your search at

www.pearsoned.ca/school/science10

Interpreting Climate Data

The graph in Figure D1.12 also demonstrates how difficult it is to detect changes in climate. According to scientists from Environment Canada, the data in the graph indicate that the average temperature in Canada increased by 1.0°C from 1948 to 1999. This was determined from the line of best fit for the data points on the graph. This was not a straightforward task, since the average temperature for some years was much warmer than previous years, and sometimes was much cooler. Also, not all regions of Canada experienced the same variations in temperature, which made the analysis even more difficult.

We do not have a complete record of Earth's past climate, and we do not yet fully understand all the factors that affect climate today. What is known, however, is that climate is very important to the biosphere and climate change could have consequences to all life on Earth.

D1.2 Check and Reflect

Knowledge

1. Describe one example of how climate affects people.
2. Describe how climate affects the life of a grizzly bear, or of another organism of your choice.
3. Could trumpeter swans survive in a hot, dry climate? Explain your answer.
4. Define climate change.
5. Explain why scientists use data from time periods of at least 30 years to look for evidence of climate change.
6. Give one example of anecdotal evidence of climate change, and one example of scientific evidence of climate change.

Applications

7. A foreign exchange student is coming to visit your class. This student has never before lived in a climate similar to yours. Write a letter in which you recommend what clothes the student should bring with him/her. Complete your letter by inviting the student to join you in one winter sport and one summer sport. Explain why each of the two sports is played only in one season.
8. Each year, a bird-watching club records the first spring sighting of a migratory bird, the golden-crowned kinglet. Their observations from 1973 to 2003 were:

1973	May 15	1984	May 8	1995	May 4
1974	May 14	1985	May 10	1996	May 2
1975	May 14	1986	May 9	1997	May 1
1976	May 13	1987	May 7	1998	Apr 30
1977	May 15	1988	May 6	1999	May 1
1978	May 11	1989	May 8	2000	Apr 29
1979	May 12	1990	May 7	2001	May 2
1980	May 10	1991	May 6	2002	Apr 30
1981	May 11	1992	May 4	2003	Apr 29
1982	May 9	1993	May 5		
1983	May 10	1994	May 3		

   a) Create a graph of these observations.
   b) Describe any trends you find in your graph.
   c) Write a hypothesis to explain any trend you observed.
   d) What kind of information could you collect to gather evidence that might support your hypothesis?

Extension

9. Although the temperature of the Okanagan Valley supports the production of fruit, there is too little rain for these trees to survive naturally. Growers therefore supply extra water by irrigation. Using print and electronic resources, find out how irrigation changed the types of plants that can survive in the Okanagan Valley. If the climate were to become even drier, which would be more affected, the native plants or the plants that depend on irrigation? Why?

Section Review

Knowledge

1. What is the biosphere?
2. How is climate different from weather?
3. In a brief descriptive paragraph, distinguish between the hydrosphere, lithosphere, and atmosphere.
4. Explain the relationship between the troposphere and the survival of humans.
5. Where in the atmosphere does the ozone layer occur?
6. Where is atmospheric dust found?
7. What two gases in Earth's atmosphere are most important to supporting life?
8. What two sources of energy warm the lithosphere?
9. What forms of water are found in the biosphere, and where are they located?
10. Describe one example of the way climate affects animals.
11. What is the difference between anecdotal and scientific evidence?
12. Identify which of the following would be examples of anecdotal evidence and which of scientific evidence of climate change.
    a) Rocky Mountain glaciers are smaller than 100 years ago.
    b) Inuit people are finding that the Arctic ice floes are breaking up earlier in the spring.
    c) Farmers are saying their crops ripen earlier now than in the past.
    d) The average temperature of Earth increased by 0.6°C over the 20th century.

Applications

13. It is difficult to include water vapour in a chart or table of the composition of Earth's atmosphere. Why is this?
14. A researcher is studying the changes in the width of growth rings in trees from a particular region, using tree cores that were collected previously. Some of the data from two core samples are presented in the following table:

Year	Width of Growth Ring (mm)	
	Sample 1	Sample 2
1959	—	2.0
1960	3.0	2.0
1961	2.0	2.0
1962	2.5	2.0
1963	2.0	2.0
1964	9.0	9.0
1965	4.0	4.0
1966	7.5	7.5
1967	3.0	3.0
1968	3.0	3.0

    a) If the trees produce wider rings under cool, wet conditions and thinner rings under dry, hot conditions, which years were hot and dry? Which were cool and wet?
    b) The researcher plans to measure the growth rings from at least 20 core samples that contain rings produced over this same time period. This work will take a long time. Why would the researcher measure so many trees?
    c) The researcher found newspaper articles from 1961 to 1963 in which local farmers reported that their crops had failed due to lack of water. What kind of evidence are these reports? Why might the researcher also be interested in this kind of evidence?
    d) The data for 1964 are very different from that from 1959 to 1963. Is this evidence of climate change? Why or why not?

Extensions

15. Create a model of the region of the biosphere that is within a 50-km radius of your school. Include the lithosphere, hydrosphere, atmosphere, and the living things that can be found.
16. Create a multi-media presentation that shows the ways in which an animal or plant of your choosing is affected by the climate of Alberta.
17. Create diagrams of a house in Alberta and a house located in a village near the equator. Show how the buildings must be different to address different climates.